Continuum and multi-scale modelling of crowd flows

Matthew Turner (Warwick)
Oksana Koltsova (Legion Consultancy)

Planning and design of pedestrian amenities (multimodal points, airports, shopping malls, theaters etc) requires an efficient, comfortable and safe walking environment for pedestrians. Other factors can also be important, such as evacuation dynamics under conditions of danger and panic. Pedestrians interact continuously with other pedestrians and their surrounding infrastructure/environment, changing their direction and speed frequently. To represent this complex movement various models has been proposed. The modelling, qualitative analysis, and simulation of crowd dynamics is a research field which is rapidly growing.

A modelling approach can be developed at three scales; namely, **the microscopic scale**, where the dynamics of each pedestrian is modelled individually in relation to other pedestrians, **the macroscopic scale**, which refers to the dynamics of locally averaged quantities similar to density, momentum and energy, and **the mesoscopic (kinetic) scale**, which corresponds to the dynamics of a probability distribution over the microscopic state of the pedestrians. A multiscale approach is therefore necessary to obtain a detailed description of the complex dynamics of pedestrians in unbounded and bounded domains. This challenge, bridging the gap between different scale aspects can be resolved using **a hybrid multi-scale model** unifying the advantages of each scale and minimising computational expenditure.

In this project, we propose to use a microscopic model similar to that employed for granular flow to the development of a continuum model similar to a model that controls the motion of fluids. We envisage the project involving a literature review the analysis of some simple simulations and the use of these to parameterise a continuum description.

We are interested in using the methodology of a continuum fluid description parametrised by systems with soft interactions and/or friction to model the motion and escape dynamics of pedestrians, e.g. in panic situations. The forces produced via interactions between pedestrians in panic-driven situations may support friction, leading to viscous-like drag in a fluid description, and/or elastic forces, leading to viscoelastic effects. Unlike passive flows, pedestrians are self-driven and so we envisage an active fluid model similar to those currently being employed to describe so-called active matter, e.g. self-driven nematic solutions.

[The scope of this project may change depending on the outcome of the Research Study Group on crowd dynamics].